Exploration of very high gradient cavities

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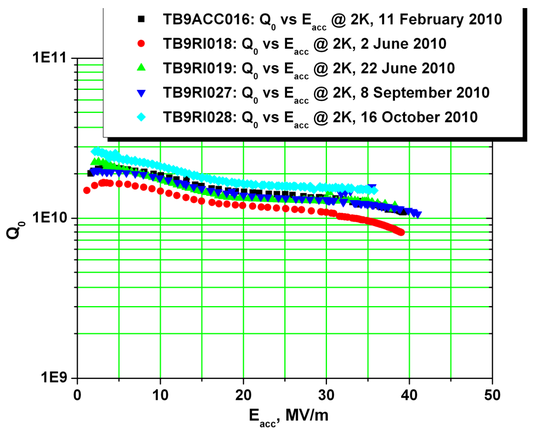
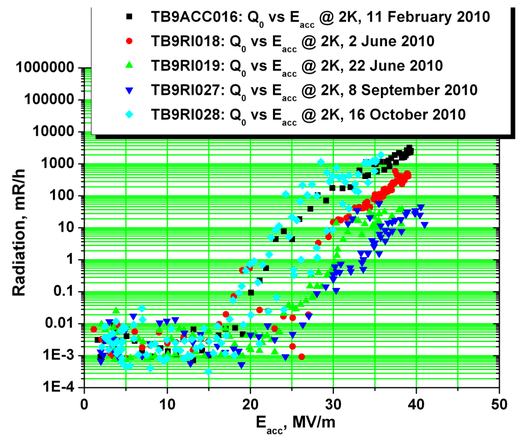
ABSTRACT: Several of the 9-cell ILC cavities processed at Jefferson Lab within ongoing ILC R&D program have shown interesting behavior at high fields, such as mode mixing and sudden field emission turn-on during quench. Equipped with thermometry and oscillating superleak transducers (OSTs) system for quench detection, we couple our RF measurements with local dissipation measurements. In this contribution we report on our findings with high gradient SRF cavities.

High gradient cavities

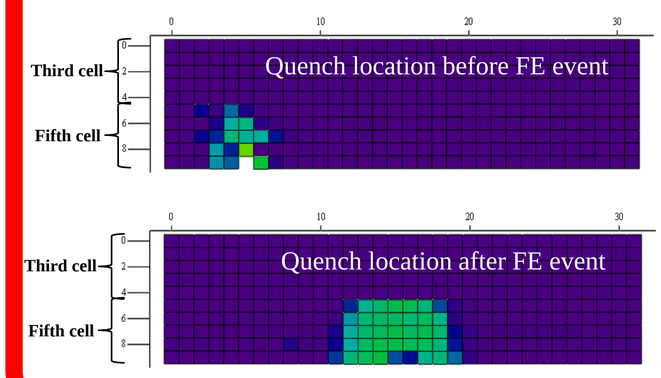




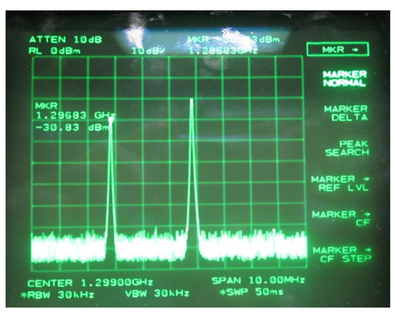
Five cavities from Research Instruments have been tested as part of ILC yield in 2010. All five cavities have met ILC specifications after the second pass. In many test advanced instrumentation such as thermometry and OSTs have been used to study performance and limitation of the cavities.

One cavity has shown sudden field emission turn-on event, which was recorded with thermometry.

TB9RI027 :
Thermometry data before
and after the event



In several cavities mode mixing at high fields was observed. Excitation of pass-band modes is unwanted phenomenon that will lead to beam degradation in real accelerators, it also makes measurement of cavity characteristics more difficult.

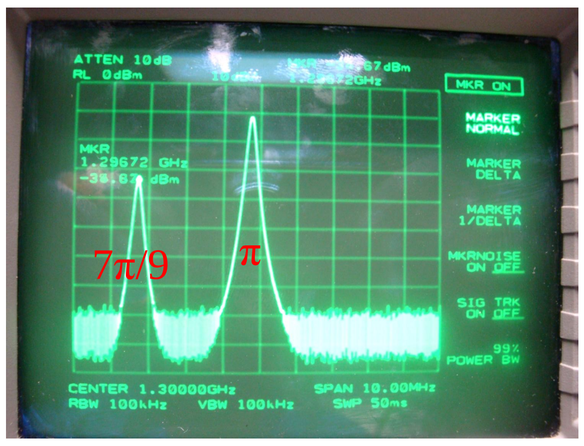


Mode-mixing results

Mode mixing has been observed during RF tests of TB9RI019 and TB9RI027. During TB9RI019 testing mode mixing was observed for π, 4π/9, and 2π/9 modes measurements. Both cavities had field emission during π mode measurements.

TB9RI019 mode mixing measurements

Above 31 MV/m we observed 7π/9 mode build up during π mode measurements. The 7π/9 mode build up started above 31 MV/m. Parked at the constant field level in π mode the cavity would eventually quench. At 32 MV/m it took 25 sec for 7π/9 mode to appear on spectrum analyzer screen and 60 sec for cavity to quench. At 38 MV/m it took less than 1 sec for 7π/9 mode to appear on spectrum analyzer screen and 8 sec to quench.

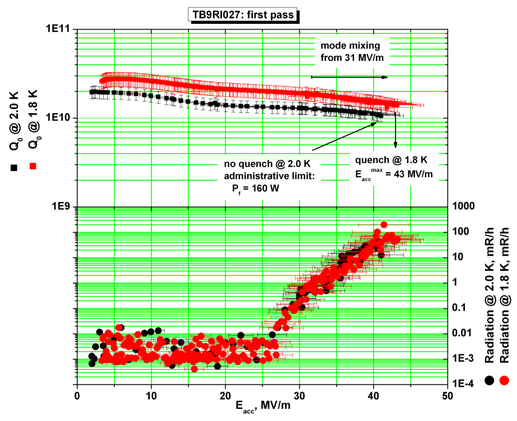


Mode mixing was observed for π, 4π/9, and 2π/9 modes measurements. 4π/9 mode mixed with 3π/9, 5π/9, and π. 2π/9 mode mixed with π/9 and 3π/9.

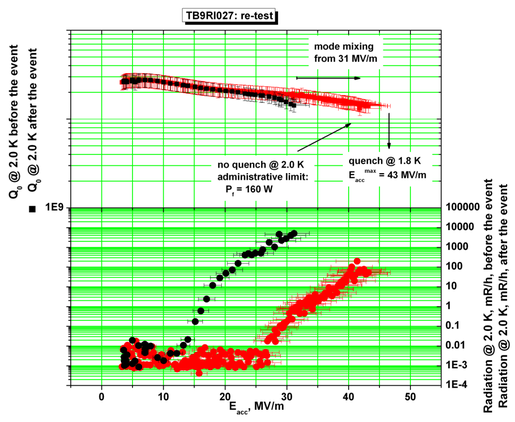
During 2π/9 mode measurement we observed mode beating: with 2π/9 mode stable on the spectrum analyzer, π/9 peak value steadily increases, 3π/9 mode decreases until a certain level, at which π/9 value drops, while 3π/9 mode peak value jumps up, and the process repeats itself.

TB9RI027 field emission event

TB9RI027 : before FE event @ 2.0 and 1.8 K



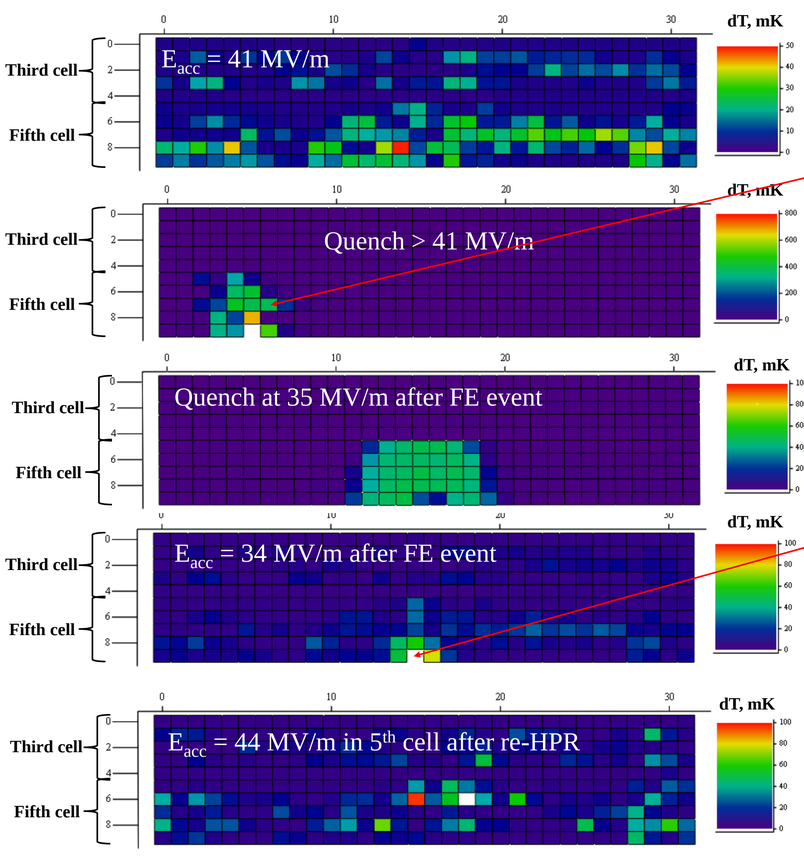
TB9RI027 : before and after FE event @ 1.8 K

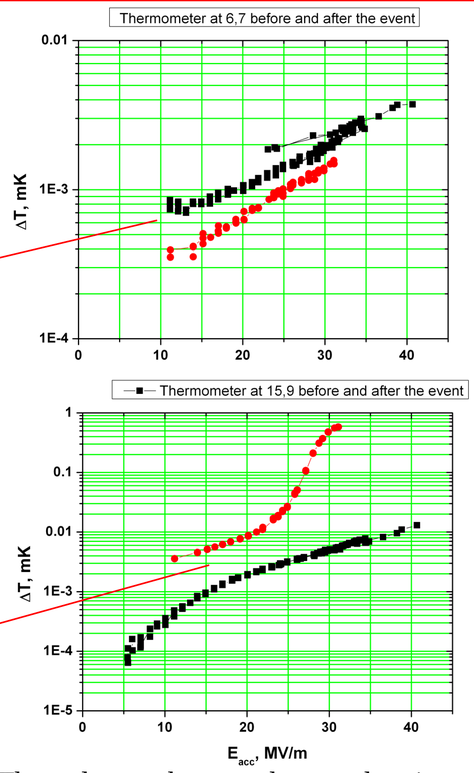


Before FE event temperature map captured at 41 MV/m shows that quench spot does not show outstanding pre-heating.

After many repetitive quenches at the original location we observed a sudden field emission turn on in a different place. After FE event there is a clear field emission heating pattern at 34 MV/m.

After re-HPR the field emission was gone. The temperature map to the left was captured in 5π/9 mode with E_{acc} = 44 MV/m in fifth cell and E_{acc} = 41 MV/m in third cell.





The data above shows heating field dependence change before and after FE event at the original quench location and new quench location. The change in T vs E_{acc} for the original quench location suggest that niobium surface modification is involved in sudden FE event.

Conclusions

Several of the 9-cell ILC cavities processed at Jefferson Lab within ongoing ILC R&D program have shown interesting behavior at high fields, such as mode mixing and sudden field emission turn-on during quench. Equipped with thermometry and OST system for quench detection, we measured sudden field emission event during repetitive quench at 41 MV/m. After the event the cavity was limited by quench at 35 MV/m with clear limiting field emitter in cell #5. Interestingly, the temperature sensor at the initial quench location showed different field dependence after field emission event, which suggests that the quench have modified RF surface at the original quench location. Additional high pressure rinsing removed field emitter and this cell reached E_{acc} = 44 MV/m without quench.

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